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A Study on Iterative Schemes for Fully Coupled Reactive Transport and Flow in Variably Saturated Porous Media

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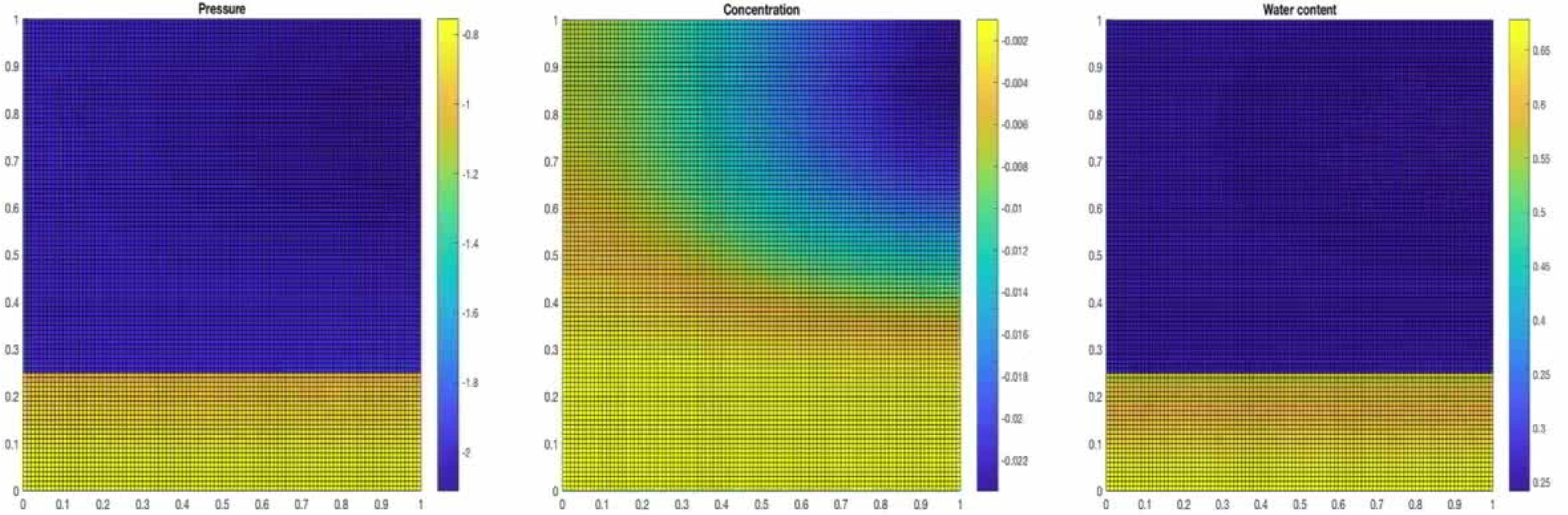
Numerical Example: Vadose zone



MRST – Matlab Reservoir Simulation Toolbox

List, Radu, 2015,A study on iterative methods for solving Richards' equation

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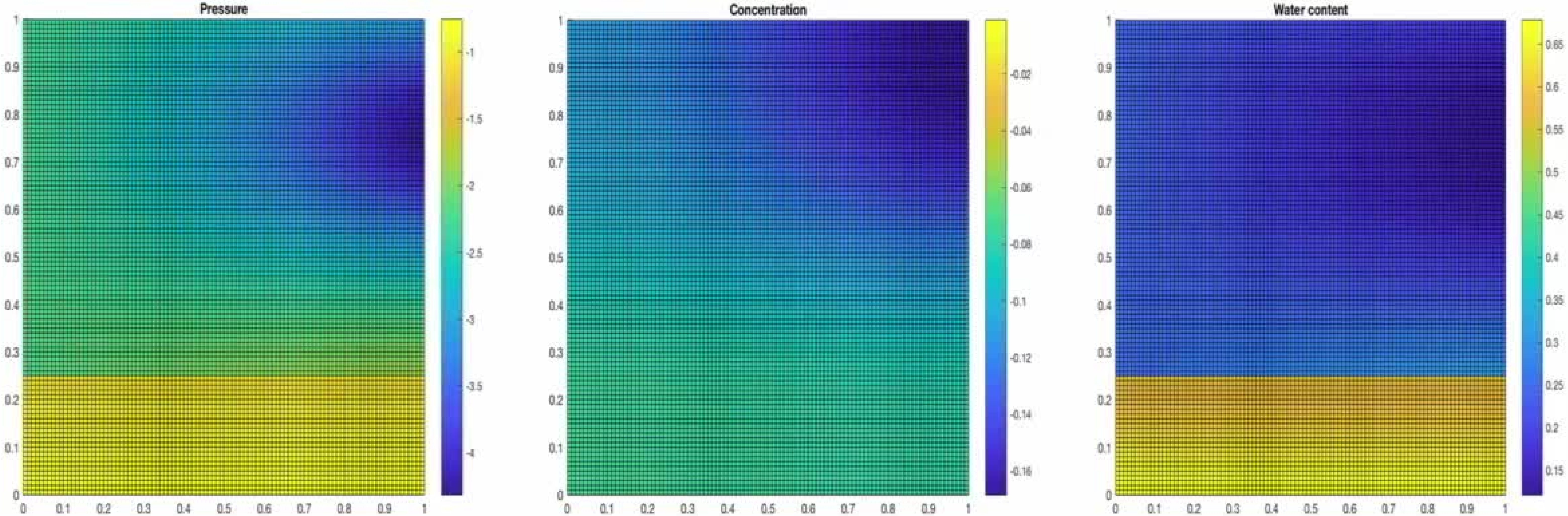

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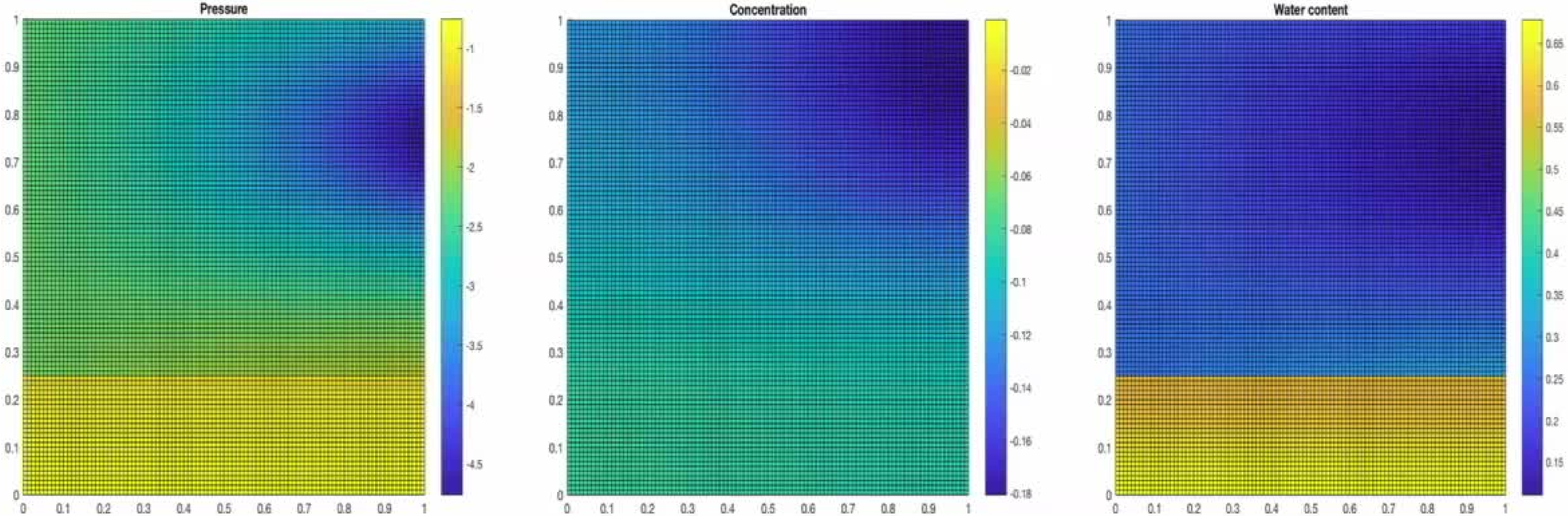

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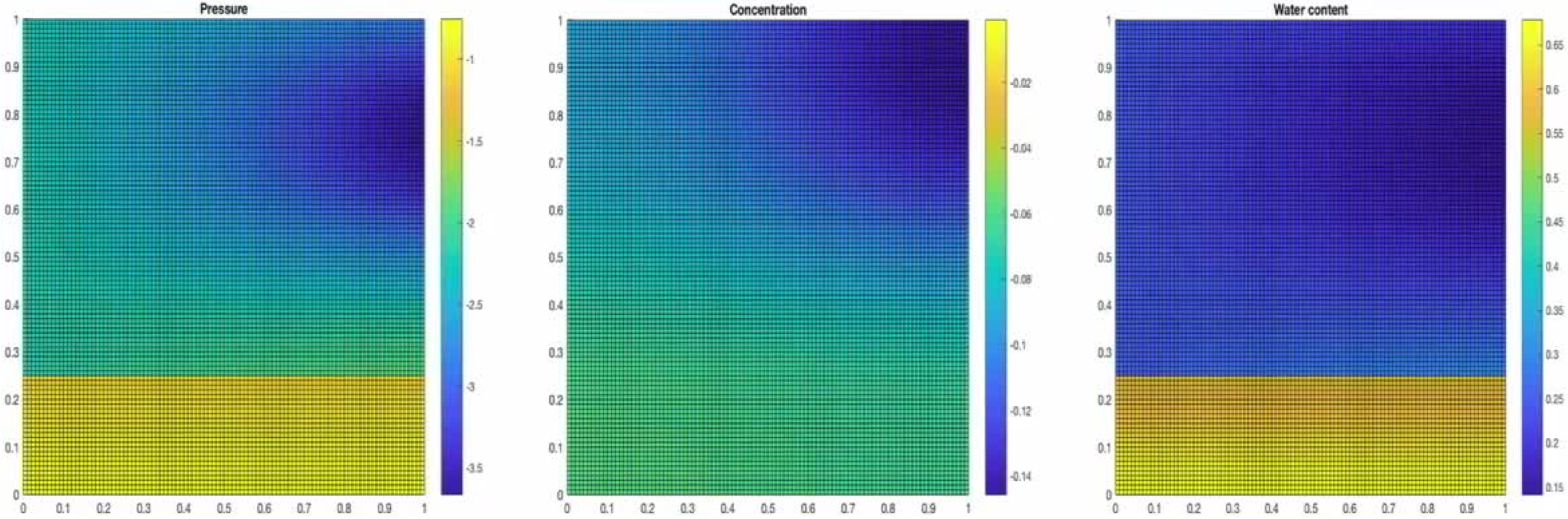

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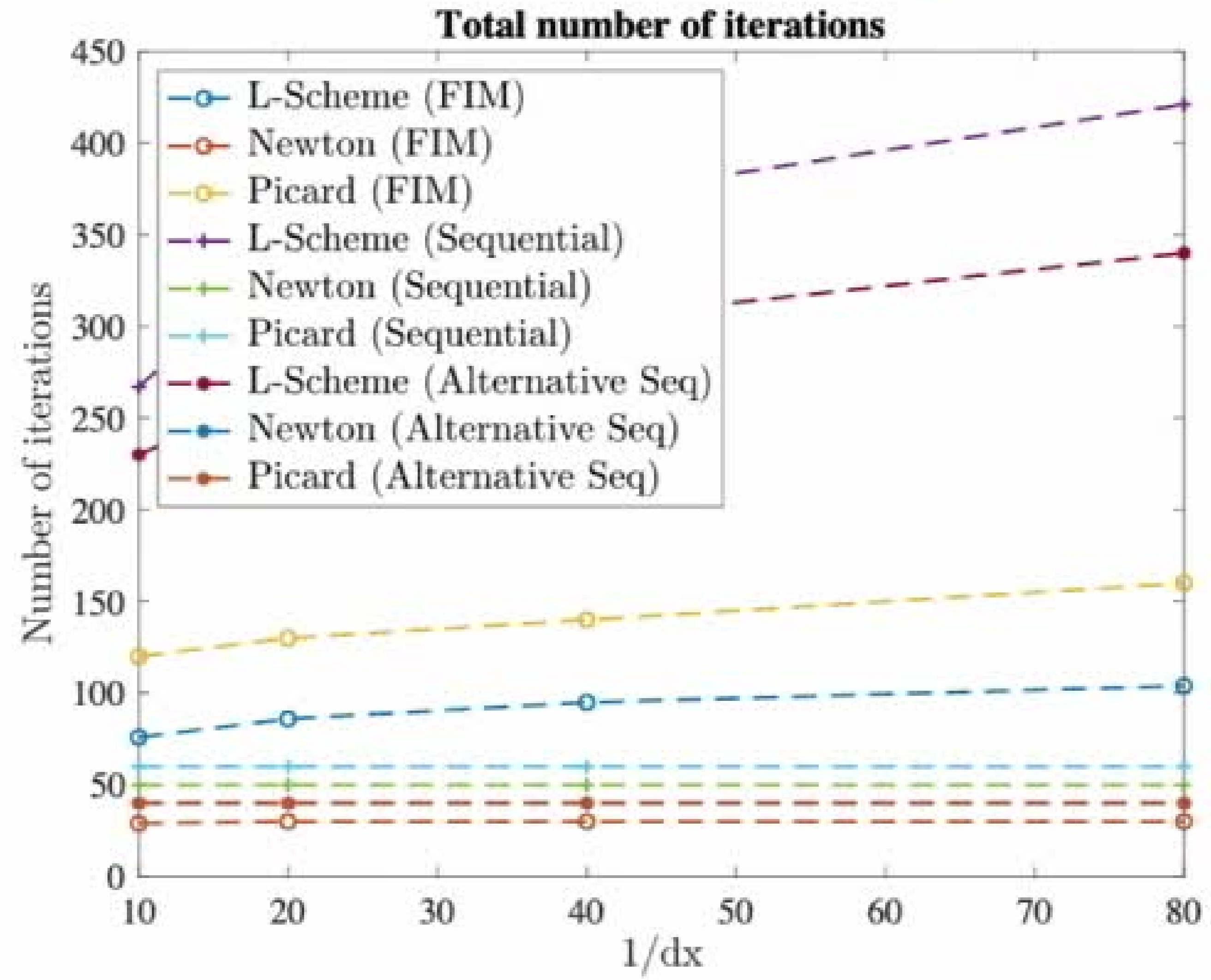
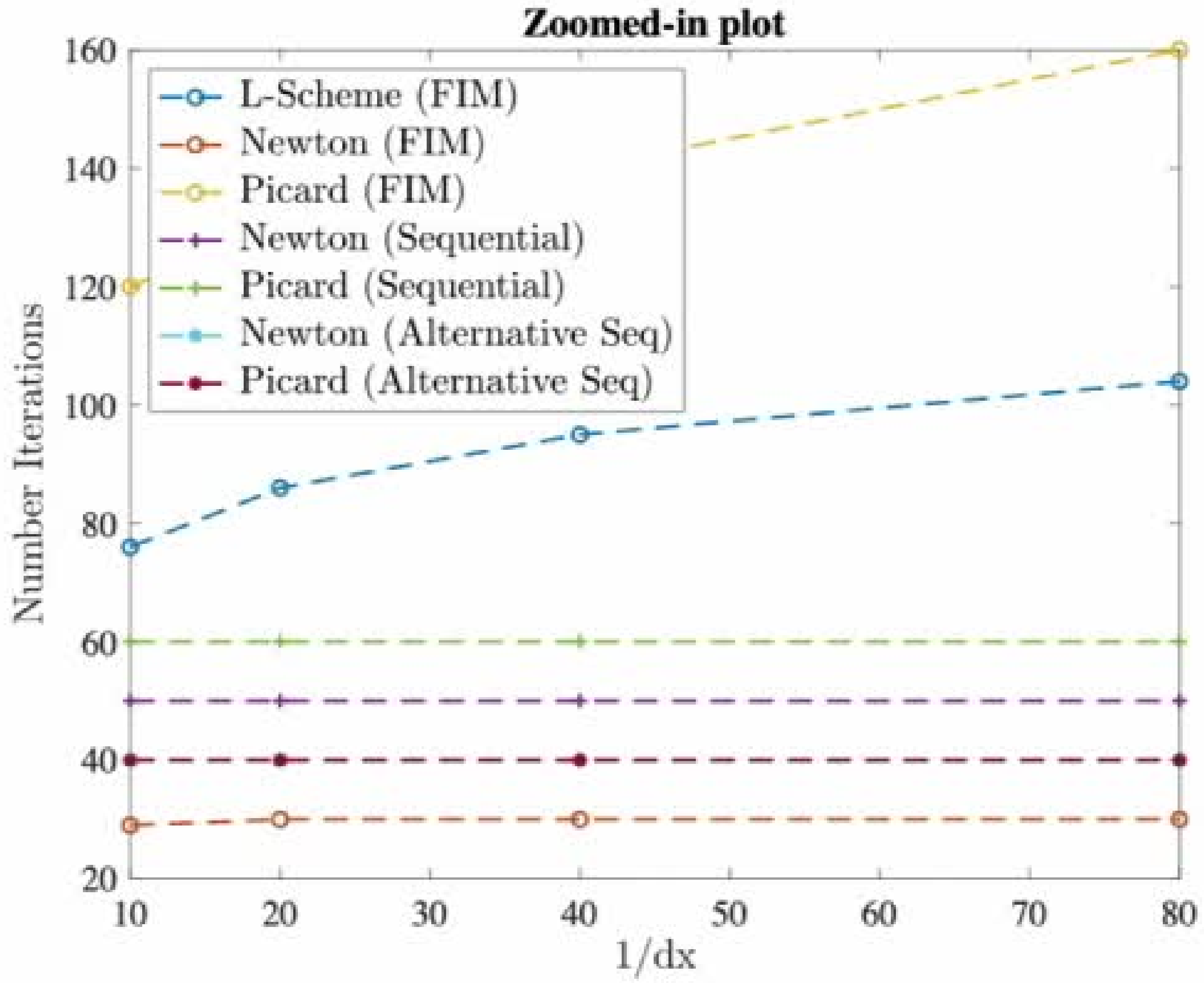
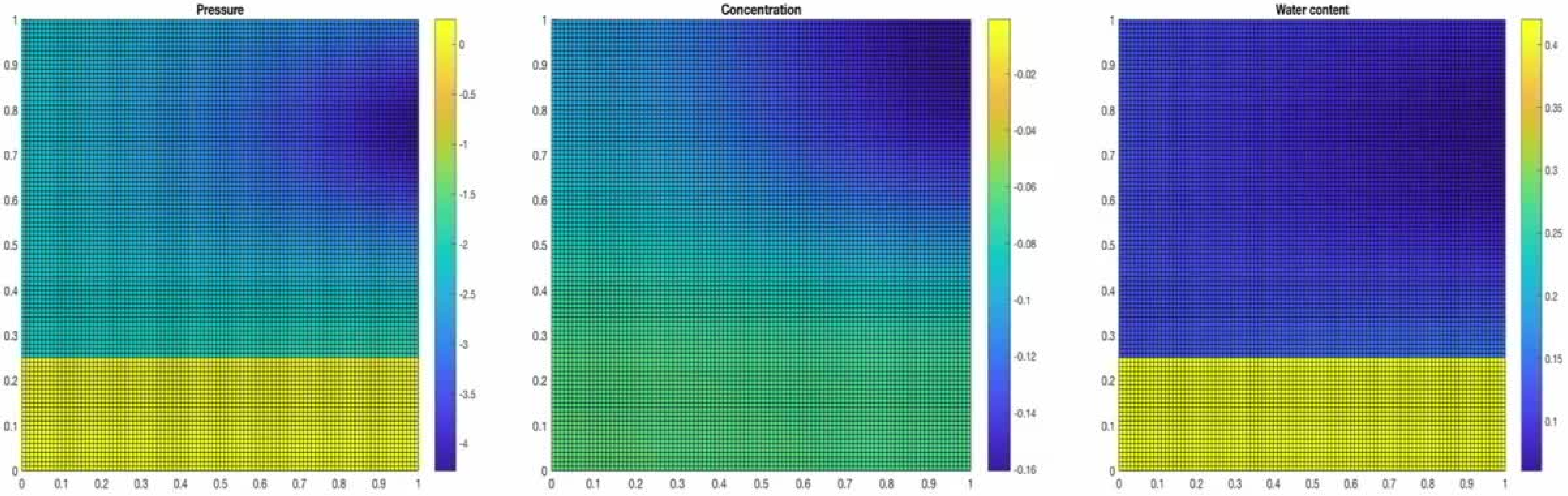




Numerical Example: variably saturated PM



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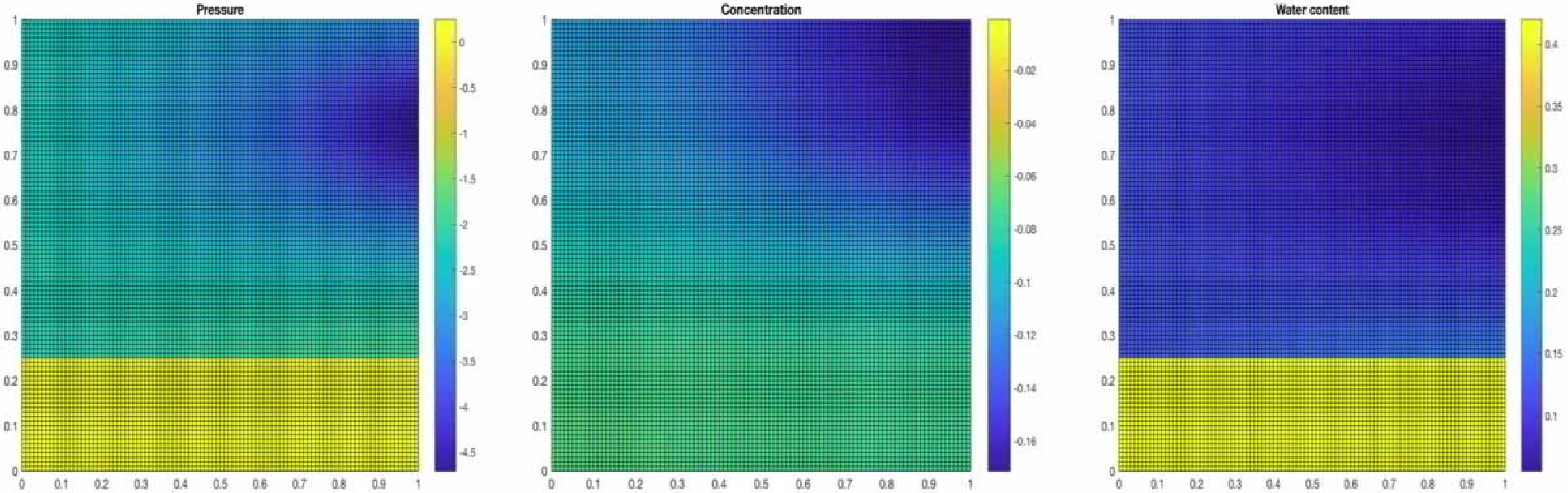

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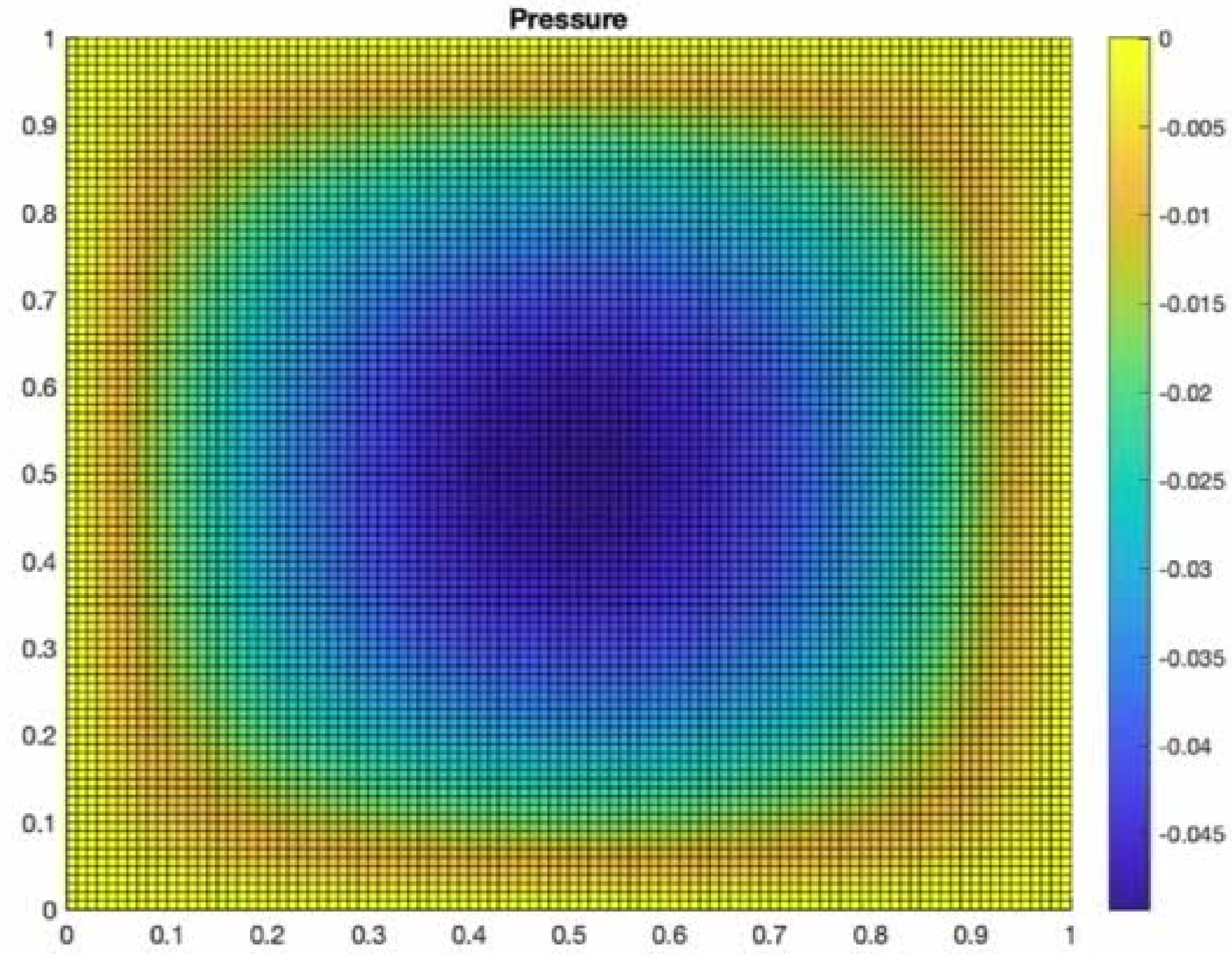
Dynamic capillary pressure

$$\frac{\partial \boldsymbol{\theta}}{\partial t} - \nabla \cdot \left(\mathrm{K}(\boldsymbol{\theta})\nabla(\Psi + \mathrm{z})\right) = \mathrm{H}_1$$

$$\frac{\partial c\boldsymbol{\theta}}{\partial t} + \nabla \cdot (-D\nabla c + q_w c) + \mathrm{R}(\mathrm{c}) = \mathrm{H}_2$$

$$\Psi + p_{cap}(\boldsymbol{\theta}) - \tau \frac{\partial S_w}{\partial t} = 0$$

Numerical example



Analytical solutions:

$$p_a = -t * x * (1 - x) * y * (1 - y)$$

$$c_a = -p_a$$

$$\theta_a = (1 - p_a^2)/2$$

VISTA

UNIVERSITAS BERGENSIS

PROJECT FUNDED BY VISTA A COLLABORATION BETWEEN THE NORWEGIAN ACADEMY OF SCIENCE AND LETTERS AND EQUINOR

Conclusion

1. The comparison between the different linearization schemes shows that **the L-scheme is the only convergent method** in particularly complex configurations,
2. The **new approach here presented appears to be a valid alternative to the common formulation**, it gives equally accurate results, requiring fewer iterations,
3. The introduction of the dynamic effects removes the non-linearity of θ,
4. Best results were obtained with $L_1 \approx 1/2\, max||\partial\theta/\partial\Psi||$ and $L_2 \approx 1/2\, max||\partial\,\theta/\partial c||$.

Dynamic capillary pressure

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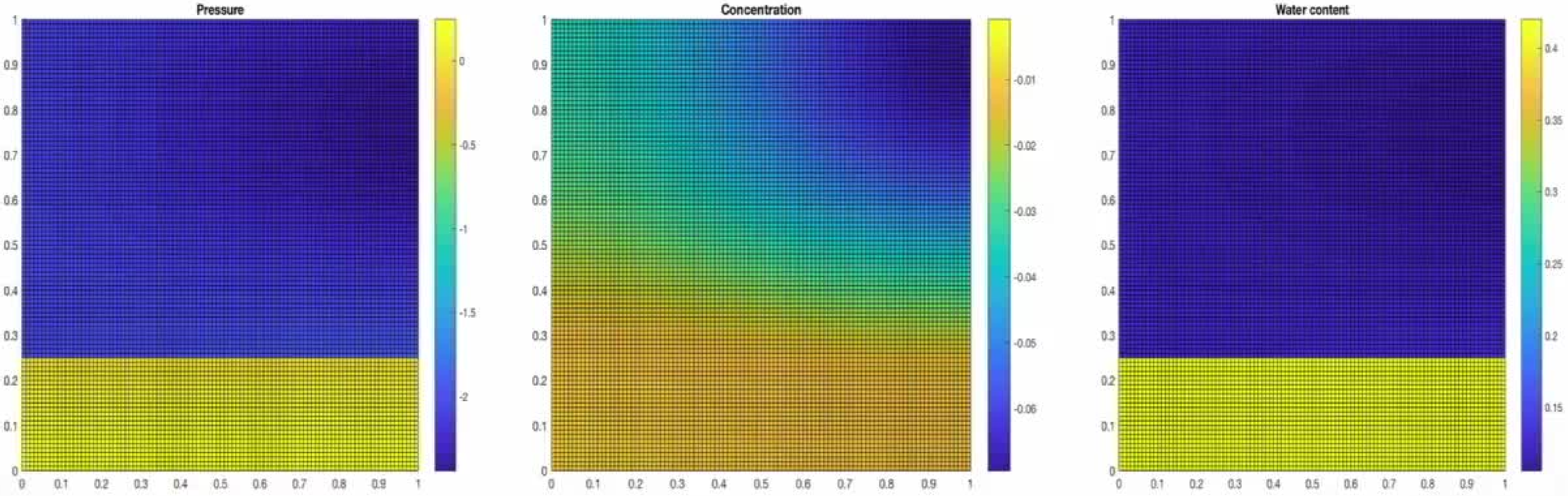

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Alternative sequential approach